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THE TRANSFER OF THE BUSHY CHARACTER FROM COWPEA (*VIGNA SINENSIS* [LINN.] SAVI) TO SITAO (*VIGNA SESQUIPEDALIS* FRUW.)[1]

J. C. Acosta and L. M. Petrache [2]

Vigna sinensis (bushy) and *V. sesquipedalis* (viny) were sparingly compatible. The few pods produced in the crossing developed a fair number of seeds.

Habit of growth and pod length in the F_1's were intermediate between the two parent extremes. In the F_2's some segregates exceeded the parents in pod length, but no increase of seeds per pod was obtained.

Six promising lines, numbered 1 to 6, were selected in the F_6 generation. Two (Lines 1 and 2) were viny; one (Line 3), intermediate; and three (Lines 4, 5, and 6) were bushy. Lines 4, 5, and 6 had tender pericarps. In both the dry and wet season tests, Lines 5 and 6 were consistently better in yield than the other lines, the parents or certain standard varieties included as checks. Line 2 did not perform satisfactorily during the dry season, neither did Line 4 in the wet season.

The bushy types matured 14 days earlier and had shorter pods than the semi-viny types. Bearing life of all the varieties was 32 days, except sitao (*Vigna sesquipedalis* [Linn.] Savi) which was 36 days.

In eating quality, Line 1 raised in the dry season was rated the best, but in the wet season test another group of tasters rated all varieties and lines as good except Alabama Crowder which was rated just fair and Cotabato which was rated very good.

There were two peaks of harvesting during the dry season. Gradual decrease in yield during first to last harvesting was noted in the wet season test

Leguminous crops have been grown in the Philippines for a long time and are very popular in many native recipes. Both the pods and the beans have been found to be highly nutritious (Ander-

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[1] Central Experiment Station Contribution No. 2030. This paper is based on the theses presented by the junior author for graduation with the degree of B.S.A. from the College of Agriculture, 1956, and by the senior author to the Graduate School, U.P., 1959, for the M.Sc. degree. The latter was on graduate fellowship at the College of Agriculture.

[2] The authors acknowledge the help of Dr. D. L. Umali who suggested the problem, Messrs. F. Bernardo, J. R. Deanon, Jr., and I. S. Santos for their criticisms of the manuscript. They are grateful to the late Dr. T. L. York for his advice and interest.

son, 1955; Rossel, *et al.*, 1946). The crops are easy to grow, have a wide range of adaptation, and can thrive even in poor soil.

Sitao (*Vigna sesquipedalis*) is a tall viny plant with long tender pods and widely spaced seeds. It requires poles or stakes for support. Expenses for poles, according to surveys of commercial fields in Bulacan, may range from ₱250.00 to ₱500.00 per hectare.

Cowpea (*V. sinensis*) is essentially bushy in habit, but it has a fibrous pericarp and its right stage of tenderness for table use is of a short duration.

Through breeding and selection, it is believed possible to combine the desirable characters of cowpea and sitao, namely, the bushy habit and the tender pod. In addition, the yield, adaptability to soil and climate, and resistance to nematode and bacterial wilt could probably be improved.

These experiments were conducted from May, 1955 to March, 1959 in the experimental fields of the Central Experiment Station and in the laboratory of the Vegetable Crops Section, Department of Agronomy, in order (1) to find if the bushy habit, earliness of maturity, and shortness of pods can be transferred from *V. sinensis* to a local variety of *V. sesquipedalis,* (2) to fix these characters in the line by successive selfing and selection of the more promising lines and (3) to make a horticultural description of the synthetic varieties thus produced, and through correlation studies, associate some characters with yield performance.

REVIEW OF LITERATURE

Kalton (1948) suggested that hybridization followed by selection is the most promising method of obtaining new and improved varieties of soy beans.

Capinpin (1936) and Davis 1945 found that high temperature influences the set of sitao pod to a greater degree than relative humidity and soil moisture.

Capinpin and Irabagon (1950) observed variability in pod color, seed coat color, maturity, pod length, and average number of seeds to a pod in sitao.

Aala (1937) observed that there was a proportional increase in seeds produced as the weight of vines increases. Of the four va-

rieties of cowpea studied, he noted a creeping habit of growth during the rainy season.

Rios *et al.*, (1946) noted that reducing distance between drill rows from 85 centimeters to 42 centimeters brought about marked increase in yield of bean varieties. They further reported that long, warm, and moist days in summer tended to reduce the yield materially and the plants had a tendency to grow tall and flower scantily.

MATERIALS AND METHODS

Several varieties of *Vigna sinensis* and *Vigna sesquipedalis* were used as parents and subsequent crosses were further tested. Brittingham (1946) differentiated these two *Vigna* species as follows:

> *Vigna sinensis*—flower is purple; seed, solid buff, brown or white with black eye; pods, short (15 to 20 centimeters), yellow when mature; pericarp, fibrous; seed, closely spaced; plant, bushy and early maturing.
>
> *Vigna sesquipedalis*—flower is yellow; pods, 30 to 40 centimeters long, variable colored, with widely spaced elongated kidney-shaped seeds; plant trailing, viny, strongly climbing if given support; matures 10 days later than *V. sinensis*.

Hybridization and Line-Selection

Culture of parental stocks. In May, 1955, three varieties of *V. sinensis* and two varieties of *V. sesquipedalis* were planted. Standard methods of culture were adopted in growing them to flowering stage.

Emasculation and crossing. To prevent selfing, emasculation was done at 4 to 6 o'clock in the afternoon and pollination of emasculated flowers made at 6 to 8 o'clock the following morning. The following crosses were made using the varieties of *V. sinensis* as the female parents:

V. sinensis		*V. sesquipedalis*
Alabama Crowder (AC)	×	Singapore (S)
Alabama Crowder (AC)	×	Tender green (TG)
Brown Crowder (BC)	×	Singapore (S)
Brown Crowder (BC)	×	Tender green (TG)
California Black Eye (CBE)	×	Singapore (S)

Planting of hybrids and parents. Each cross was planted side by side with the parents in September, 1955 and observed for hybrid vigor.

Suspected selfed plants were discarded.

F_2 seeds obtained from naturally selfed F_1's were planted in January, 1956 with 10 F_1's and 10 parents, and observed separately for the vine habit, maturity, and length of pod.

F_5 seeds [3] and seeds of Cotabato [4] sitao, Singapore sitao (viny parent); and New Era (standard bush variety), and Alabama Crowder [5] (bush parents) were then planted.

Six plantings were made, using in each generation the seeds of the selected lines. The first planting (F_5) which was done on June 3, 1957 and the second (F_6) made on August 12, 1957 were for purification of the segregating lines. Six promising lines numbered 1, 2, 3, 4, 5, and 6 were selected. All except one were obtained from crosses between California Black Eye × Singapore; Line 3 was obtained from a cross between Alabama Crowder × Singapore.

The third planting (F_7) done on October 21, 1957, was for multiplication of seeds. Lines 2 and 5, New Era, and Alabama Crowder were planted to produce enough seeds for a yield test.

Yield and Quality Tests

Two green-pod yield tests were conducted, one of which was in the 1957-58 dry season and the other in the 1958 wet season. Dry seed yield test was conducted in 1958-59 dry season. Cultural operations were generally the same in all tests. In addition to the parent varieties, two standard varieties, Cotabato and New Era, were included as check.

Green-pod yield test. The dry season test was planted on January 21, 1958 and the wet season test on May 28, 1958 in a field 20 × 25 meters. The simple randomized complete-block design with four replications was used. Lines and varieties were planted in two-row plots, five meters long. Plots were set 100 centimeters apart and the rows at 80 centimeters apart. Setting in the row was 25

[3] In the F_3 and F_4 plantings the writers assisted Dr. T. L. York in the selection of promising lines.
[4] Selected by Dr. T. L. York in Cotabato.
[5] Obtained by Dr. T. L. York from the United States.

centimeters between plants for the bushy type; 100 centimeters, for the viny types. Complete fertilizer (12-24-12) was applied in liquid form at the rate of 750 kilograms per hectare. The fertilizer solution was made up by dissolving 1 kilogram of fertilizer for every 5 gallons of water. Added into the solution were the trace elements Fe, Mn, Cu, Zn, B, and Mo. Three weeks after planting, another application of the complete fertilizer solution at the same rate was made. The plants were irrigated in the dry season since rainfall was insufficient.

Viny varieties were provided with poles. Proper control measures were instituted against the pests and diseases attacking the plants. In the wet season, D-D (dichloropropane, dichloropropene) was injected to the soil at the rate of 1.8 milliliter per square foot so that all soil-inhabiting disease organisms would be killed.

Green pods were harvested when they were ready for table use. From the first harvest, data on length of pods and closeness of seeds were taken. Number of seeds per 10 centimeters middle section of a pod was used as the measure for closeness of seeds. Harvesting was started when about one half of the plants had pods and subsequent harvestings were made at 4-day interval. The length of bearing period was noted.

Vigor of the plants at the flowering stage was rated as follows: 1 for poor; 2, fair; 3, good; 4, very good; and 5, excellent.

Green-pod quality test. Quality tests were run in the dry and wet seasons with the help of two panels of tasters. Quality was rated according to tenderness, flavor, and sogginess of pods. The ratings had the same descriptive equivalents as in plant vigor.

Dry seed yield test. The crop in which yield of dry seed was taken was planted on December 6, 1958. All procedures and details on the cultural practices and observation of performance were similar to those in the dry season green-pod yield test except that two spacings were used: 20 plants per meter and 30 plants per meter. Lines 2 and 4 were not included. Harvesting by priming was done when about 50 per cent of the plants had all their pods dried.

Dry seed quality test. A taste test of the cooked dry seeds were also run on the different lines. The scheme of rating used in this test was the same as that for the green pod quality test.

RESULTS AND DISCUSSION

Compatibility between Vigna sinensis and Vigna sesquipedalis. Gauged by the low ratio of number of pods set to number of flowers pollinated, the two species may be considered weakly compatible or largely incompatible (table 1).

TABLE 1.—*Compatibility between Vigna sinensis and Vigna sesquipedalis.*

CROSSES	TOTAL NUMBER			POD SET PER FLOWER POLLINATED	AVERAGE NUMBER OF SEEDS/POD SET
	Flowers pollinated	Pod set	Seeds produced		
AC × S	86	11	77	.127	7.00
AC × TG	68	14	99	.205	7.07
BC × S	91	6	46	.065	7.66
BC × TG	61	8	62	.131	7.75
CBE × S	94	12	76	.127	6.33
AC × (AC × S)	13	2	18	.153	9.00
S × (AC × TG)	11	2	14	.181	7.00
S × (CBE × S)	15	3	17	.200	5.66

Alabama Crowder (AC) 15.03 seeds per pod when continually selfed.
Brown Crowder (BC) 13.66 " " " " " "
Singapore (S) 15.20 " " " " " "
Tender Green (TG) 14.66 " " " " " "
California Black Eye (CBE) 9.36 seeds per pod when continually selfed.

According to one of the criteria of compatibility, viz., seeds produced per pod set when crossed divided by seeds produced per pod set when naturally selfed, California Black Eye (CBE) as the female parent was more compatible with the sitao pollens than any other cowpea varieties. However, it should be remembered that CBE is a naturally poor seed yielder; hence, even a low count of seed per pod in the hybrid can have an apparently high compatibility. Degeneration of pods before maturity was one cause of low pod setting. This phenomenon was also observed by Roy and Richarria (1946) when they crossed short-podded bushy with long-podded viny plants. The dry and warm weather was deleterious to pod setting.

Growth habit. The F_1's were intermediate between bushy and viny.

The F_2 plants varied considerably in degree of bushiness.

Pod maturity. Pod maturity was reckoned as the number of days from planting to ripening of the first three pods.

Some plants in the F_2 matured as early as the early parent but some were later than the late parents.

The earlier parent (California Black Eye) matured in 55 days, while the later parent (Singapore) matured in 69 days. The F_1's and F_2's matured in 54 to 67 days, the F_1's a little earlier than the respective means of the parents. This leads one to assume that earliness is partially dominant.

Pod length. The short-podded parents averaged about 16 centimeters and the long-podded ones, 25 centimeters or more. In four of the five crosses, the F_1 and F_2 means were essentially the same and were intermediate between the parents. An exceptional case, however, appeared in Alabama Crowder × Singapore where the F_2's had, on the average, distinctly shorter pods than the F_1's. These findings on maturity and pod-length confirmed those of Capinpin (1935), Brittingham (1948), and Roy and Richarria (1948).

Seeds per pod. The mean values of seeds per pod for all the parents were essentially the same except that of CBE which was considerably low. As in other characters, the F_1's and F_2's were intermediate between the parents, except those of CBE × Singapore.

Selection. If only one factor pair is involved and there is no selection pressure for a given genotype, 93.75 per cent of the plants should be homozygous in the F_5 and 99.09 per cent in the F_{11}[6].

The return to homozygosity can be made faster with the aid of selection in later generations than the average expectation. The F_4 showed homozygosity in the characters viz., earliness, productivity, length (medium), and tenderness of pods. Sorting seeds according to color insured the retention of a wide variety of seed colors.

The characteristics of the 6 selected F_6 lines, parent varieties, and check varieties are shown in table 2.

Yield Tests of Selected Lines

Green pod yield. Of the 10 lines and 4 varieties used in dry season test, Lines 5 and 6 and the Cotabato variety were outstanding. They yielded about 14 kilograms per 10-meter row as compared to New Era which yielded about 9 kg./plot (table 3).

---

[6] $\frac{(2r-1)^n}{(2r)^n}$, is the formula for calculating average (expected) percentage homozygosity after r selfings and involving heterozygosity for n independently inherited factor pairs in the F_1 cross assuming no selection.

TABLE 2.—*Horticultural description of the lines of the F_6, parents, and standard varieties* [a]

CHARACTER	LINE 1	LINE 2	LINE 3	LINE 4	LINE 5
Plant:					
1. Growth habit	Bushy, erect, and determinate	Prostrate and indeterminate	Creeping and indeterminate	Prostrate and indeterminate	Prostrate and indeterminate
2. Mode of branching	Many (5-8)	Fair (3-5)	Fair (3-5)	Fair (3-5)	Many (5-8)
3. Maturity	48 days	48 days	58 days	58 days	53 days
4. Bearing life	32 days	32 days	32 days	32 days	32 days
Leaves:					
1. Bases	Oblique	Oblique	Oblique	Oblique	Oblique
2. Apices	Acute	Acute	Acute	Acute	Acute
3. Color [b]	Deep dull yellow green	Empire green	Chromium green	Chromium green	Empire green
Inflorescences:					
1. Origin	Axillary	Axillary	Axillary	Axillary	Axillary
2. Color					
a. Standard	White	Yellow	White	Cream	Cream
b. Petal	White	Light violet	Light violet	Light violet	Light violet
3. Length of peduncle	20-35 cms.	20-35 cms.	20-35 cms.	20-35 cms.	20-35 cms.
Pods:					
1. Color [b]	Pale turtle green	Light turtle green	Pale turtle green	Pale fluorite green	Deep dull yellow green
2. Length	26 cms.	28 cms.	23 cms.	20 cms.	22 cms.
3. Diameter	9-10 mm.	9-10 mm.	9-10 mm.	7-8 mm.	8-9 mm.
4. Texture	Brittle, soft	Brittle, soft	Brittle, soft	Brittle, semi-fibrous	Brittle, semi-fibrous
Seeds:					
1. Color	Creamy white	Black blotched w/ white at tip	Reddish brown	Reddish brown	Black
2. Weight of seed	.21 grams	.20 grams	.19 grams	.14 grams	.20 grams
3. No./10 cms. pod	5 seeds	5 seeds	8 seeds	9 seeds	7 seeds
4. Number per pod	12 seeds	13 seeds	15 seeds	17 seeds	13 seeds

[a] Described with the help of Mr. G. Lugod of the Department of Agricultural Botany, College of Agriculture, U.P.
[b] Ridgway, R., "Color standards and color nomenclature," Washington D.C., 1912.

Table 2 (Continued)

CHARACTER	LINE 6	A. CROWDER	NEW ERA	SINGAPORE	COTABATO
Plant:					
1. Growth habit	Prostrate and indeterminate	Prostrate and indeterminate	Prostrate and indeterminate	Twining and indeterminate	Twining and indeterminate
2. Mode of branching	Many (5-8)	Fair (3-5)	Many (6-10)	Many (5-8)	Many (5-8)
3. Maturity	53 days	53 days	58 days	62 days	62 days
4. Bearing life	32 days	32 days	32 days	36 days	36 days
Leaves:					
1. Bases	Oblique	Oblique	Oblique	Oblique	Oblique
2. Apices	Acute	Acute	Acute	Acute	Acute
3. Color [b]	Empire green	Empire green	Deep dull yellow green	Chromium green	Deep dull yellow green
Inflorescences:					
1. Origin	Axillary	Axillary	Axillary	Axillary	Axillary
2. Color					
a. Standard	Cream	Yellow	Cream	Yellow	Yellow
b. Petal	Light violet	Violet	Violet	Cream	Violet
3. Length of peduncle	20-35 cms.	20-35 cms.	20-35 cms.	10-20 cms.	10-20 cms.
Pods:					
1. Color [b]	Deep dull yellow green	Chromium green	Light turtle green	Pale fluorite green	Light turtle green
2. Length	23 cms.	18 cms.	16 cms.	37 cms.	39 cms.
3. Diameter	8-9 mm.	7-8 mm.	7-8 mm.	8-9 mm.	8-9 mm.
4. Texture	Brittle, semi-fibrous	Hard, fibrous	Hard, very fibrous	Brittle, soft	Brittle, soft
Seeds:					
1. Color	Red	Creamy brown	Gray	Red, blotched w/ white at tip	Reddish, brown
2. Weight of seed	.22 grams	.19 grams	.16 grams	.18 grams	.16 grams
3. No./10 cms. pod	7 seeds	10 seeds	10 seeds	5 seeds	5 seeds
4. Number per pod	13 seeds	16 seeds	18 seeds	18 seeds	18 seeds

TABLE 3.—*Mean green pod yields in kilograms per 4-square meter plot of the selected lines and varieties in the 1957-58 dry season and 1958 wet season*

LINE OR VARIETY	DRY SEASON	WET SEASON	VARIETY MEANS
Line #6	14.89	9.10	11.99
Line #5	13.91	8.45	11.18
Cotabato	13.93	5.82	9.87
Alabama Crowder	12.75	6.76	9.75
Line #1	11.70	6.82	9.26
Line #3	11.48	6.96	9.22
Line #4	12.09	5.15	8.42
Line #2	10.22	6.66	8.44
Singapore	10.81	5.00	7.95
New Era	8.90	4.45	6.67
Means of Season [a]	12.06	6.52	
H.S.D. .05			2.23

[a] Highly significant difference.

In the wet season test, there was about 50 per cent reduction in the green pod yield when frequent heavy rains caused the dropping of flowers.

As in the dry season test for green pod yield, Lines 5 and 6 were the outstanding yielders. New Era yielded low in both dry and wet season tests.

Vigor at flowering. In the wet season test, the vigor of Lines 5, 6, and New Era was excellent, whereas that of the viny varieties was fair.

Length of pod. Differences in length of pod among some of the varieties were highly significant (fig. 1). Pods of the viny varieties were long (about 38 centimeters); of Lines 1 and 2, medium; of Lines 3, 4, 5, and 6, short (21 centimeters).

Diameter of pods. In both tests, the selected Lines 1, 2, and 3 were considered fat or fleshy. Line 3 had a mean diameter of 10.1 millimeter; Line 5, an average of 8.8; and both Lines 6 and AC, 8.9 millimeters.

Closeness of seeds in the pod. Statistical analysis showed that there were significant differences among the different varieties in the degree of closeness of seeds within the pod. Seeds of the bushy

types were close with about 9 seeds per 10 centimeter of the middle section of the pods, and those of the viny types were far apart with a mean of 5 seeds for the same portion of the pod.

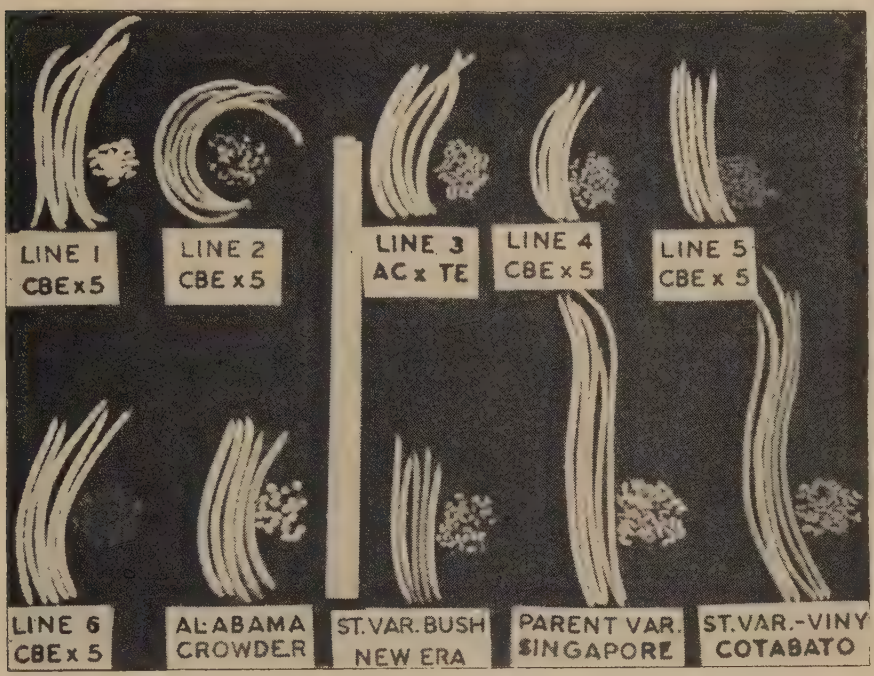

Fig. 1.—Pods and seeds of the lines, parents ,and standard varieties. (*Photographed by the Photographic Division, U.P.C.A.*)

Dry seed yield test. Significant differences were obtained among the different lines and varieties in weight of dry seeds produced. New Era was the highest yielder and had the most seeds per pod. Line 6 placed second. The poorest yielder was Line 1. Length of pod was not related to the number of seeds per pod.

Spacing and variety interaction. Table 4 shows that the varieties tended to respond similarly at the two spacings.

Pests and diseases. Bean fly, *Agromyza phaseoli* Cow. attacked the seedlings. Yellow squash beetle *Ceratia similis* Oliver; Aphid, *Aphis laburni* Caltenback; bean eye caenid, *Catochrysaps enejins* Fabr., and an unidentified moth frequented the plants and pods of all the varieties.

TABLE 4.—*Mean dry seed in kilograms per 5 square-meter plot in the 1958-59 dry season*

LINE OR VARIETY	20 PLANTS/METER	30 PLANTS/METER	VARIETY MEAN
Line #6	1.02	0.80	.91
New Era	0.97	0.81	.89
Line #5	0.83	0.75	.79
Line #3	0.75	0.69	.72
California Black Eye	0.77	0.66	.72
Line #1	0.61	0.58	.58
Spacing Mean	.83	.72	
H.S.D. for .05			0.06
variety mean .01			—

Damping-off caused by *Rhizoctonia solani* Kuhn attacked the seedlings and *Sclerotium roflsii* Sacc. killed many plants. *Marmor phaseoli* Holmes or bean mosaic was also observed.

Bearing life. The bearing life of the experimental plants was effectively prolonged by irrigation and proper pest control. Length of bearing was approximately 40 days from the first to the last harvest of marketable pods.

The heavy rains and the typhoons, however, could have shortened the bearing life of the plants in the wet season planting.

Quality tests. Most of the tasters rated the green pods of Line 1 as excellent, tender and juicy with a mean of 4.7 (table 5) in the

TABLE 5.—*Quality and texture of the green pods of the lines, parents and standand varieties in the 1957-58 dry season and 1958 wet season*

LINE OR VARIETY	MEAN RATINGS		DESCRIPTION
	Dry season	Wet season	
Line #1	4.7	3.1	Tender, somewhat sweet, juicy
Line #2	3.4	2.9	Tender, semi-fibrous
Line #3	3.3	3.1	Tender, semi-fibrous
Line #4	2.9	2.9	Tender, semi-fibrous
Line #5	2.8	3.2	Brittle, semi-fibrous
Line #6	3.1	3.1	Brittle, semi-fibrous
Alabama Crowder	2.9	2.2	Brittle, fibrous
New Era	3.0	2.9	Brittle, fibrous
Singapore	3.7	3.2	Tender, semi-fibrous
Cotabato	2.8	3.6	Semi-tender, fibrous, juicy

dry season test. Singapore was second with 3.7, followed by Lines 2, 3, and 6. In the wet season, almost all lines and varieties were rated good (2.9 to 3.2), except Alabama Crowder which was rated just fair (2.2) and Cotabato, which was rated almost very good (3.6). Differences in both seasons were not statistically significant.

NOTES AND OBSERVATIONS

Yield tendency of 11 harvests at 4-day intervals. In the dry season test, two peaks of harvesting green pod was attributed to the periodic blooming. Harvesting was at its peak in about 8 days and the decrease after that was gradual.

Weight of seeds. Seed weights of the lines and varieties varied significantly. The seeds of Line 4, New Era, and the viny varieties were the lightest and those of Line 6, heaviest with an average weight of 2.2 grams per 10 seeds. There was no consistent association of seed weight and yield.

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GROWTH OF YOUNG COCONUT PLANT IN SAND CULTURE [1]

J. R. Velasco, E. V. de Guzman and B. T. Mercado

The plants suffering from nitrogen deficiency were stunted and lacked succulence. The leaves were short, but well proportioned and the yellow leaflets were stiff. Along the midribs buff colored blotches were frequently noticed.

The minus-phosphate plants were stunted and rosetted. The dark-green leaves were usually not fully exerted from the stipules or "guinit". There was severe drying of old leaves.

The minus-potassium plants developed little dots along the margins of old leaves. In severe cases, they coalesced and gave the leaves the appearance of "firing."

The minus calcium plants were tall and slender with sparse leaves taking on a "tucked in" appearance. Petioles were deep yellow or orange, indicating that plants were rich in anthocyanin. Orange blotches along midribs were frequent.

The minus magnesium plants had elliptical water-soaked or translucent spots along the margins of old leaves. Old drying leaves assumed a "bronze" appearance. Plants were big and deceptively healthy.

The minus-sulfate plants became yellow much later than the minus-nitrogen plants. The mature leaves progressively lost their green color from the margins of the leaflets towards the midrib, so that the green seemed to form a haze on a yellow background. The rachis may be weak and pliant. Although the plant may be short and rosetted it may produce many leaves.

The plants in the minus-micro-nutrient treatment were similar to the plants receiving the complete solution until about the middle of 1958 or about 45 months of treatment. Then the plants produced thick, brittle young leaves. This was followed by leaves with malformed leaflets and eventually by leaves with no leaflets at all. This characteristic was ascertained to be caused by boron deficiency

This is a report on the latter part of the experiment which was started in 1954 and covers the period from May, 1956 to August, 1959. The early part of the study was reported by Velasco and Fertig in 1956. The objects of the experiment were (1) to catalogue the de-

[1] Central Experiment Station Contribution No. 2031. Research Project 529.

ficiency symptoms on coconut of the different essential elements, (2) to note how immediate the symptoms appear after withdrawing the element and how soon plants recover their normal characteristics upon supplying it, and (3) to determine changes in the composition of the leaves of plants suffering from nutrient deficiency.

MATERIALS AND METHODS

The cultures. On May 9, 1956, 32 of the potted plants which were started in 1954 were transferred to tarred 55-gasoline drums, one plant to a drum. Each drum contained about 290 kilograms of acid-washed white sand. This came from the same stock being used by the San Miguel Brewery Co. in the manufacture of beer bottles and is reportedly mined in the shores of Palawan Island.

When feasible, the potted plants in the earlier treatments were given the same treatments in the drums. An exception was made in that plants held in reserve and maintained in the complete solution were used in the minus-nitrogen cultures instead of plants in the minus-nitrate or the minus-ammonium culture. There were eight cultures in all: the control or the culture receiving all the essential elements and the seven cultures deficient in nitrogen, phosphorus, potassium, sulfur, magnesium, calcium, and the minor elements (iron, boron, copper, manganese molybdenum, and zinc).

Method. Each plant received two liters of solution per week until December 1957, and four liters a week until August 31, 1959. Hoagland's solution No. 2 was modified in such a way that one element was eliminated at a time (table 1). To supplement the water

TABLE 1.—*Composition of Hooglands' modified solutions for the various deficiency treatments*

DEFICIENCY TREATMENT	PLANT NUMBERS	SALTS [a] KNO_3	$Ca(NO_3)_2$	$MgSO_4$	$NH_4H_2PO_4$
Complete	103, 122, 143, 156	√	√	√	√
Minus nitrogen	95, 105, 111, 121	(KCl)	($CaCl_2$)	√	(NaH_2PO_4)
Minus phosphate	100, 115, 117, 126	√	√	√	(NH_4Cl)
Minus potassium	96, 102, 137, 169	($NaNO_3$)	√	√	√
Minus calcium	99, 147, 162, 166	√	($NaNO_3$)	√	√
Minus magnesium	93, 98, 114, 171	√	√	(Na_2SO_4)	√
Minus sulfate	116, 129, 145, 165	√	√	($MgCl_2$)	√
Minus microelements	109, 161, 163, 173	√	√	√	√

[a] Potassium nitrate was 0.006 molar (M); calcium nitrate, 0.004 M; magnesium sulfate, 0.002 M and mono-ammonium phosphate, 0.001 M. When a salt was substituted for another, it was supplied in the same concentration as the displaced salt.

supplied in the culture solution, additional rain water or distilled water was supplied to the plants during sunny days. There were also a few instances during the dry season when, for lack of both rain and distilled water, tap water was used.

In cases where the growth of the plants was severely retarded, complete solution was temporarily supplied them so that they would not die. This treatment incidentally provided opportunity to observe the time it would take plants to recover their normal characteristics, and on being returned to the deficient culture, the time needed to develop the deficiency symptoms. Summary of these treatments is presented in table 2.

The plants were sprayed weekly with either dithane or parzate, to control a fungus disease which was tentatively diagnosed as caused by *Helminthosporium* sp. As an added control measure, some of the completely diseased leaves were cut off and burned. To control the scale insects, monthly sprayings of EPN were made.

Measurements of the height and diameter of the stem, together with leaf counts were recorded monthly. A representative plant from each treatment was photographed every two months during the early part of the experiment, but starting in 1958, the pictures were taken every six months.

Leaf samples were gathered beginning July 19, 1957 and every three months thereon until May, 1958; then, every six months until September, 1959. Every other leaflet on both sides of the rachis of the oldest functional leaf and from the youngest fully formed leaf was taken, and the samples from plants of the same treatment were pooled. The leaves from plant No. 173 of the November 29, 1958 sampling, were separated from the rest of the micro-nutrient-deficient samples because of the modified treatment given it.

The samples were placed immediately in a forced draft oven at a temperature of about 100°C. When dried, the midribs were removed and the remaining leafblades were ground in a Wiley mill with a 40 mesh sieve.

Total nitrogen was determined by the modified semi-micro Kjeldahl method. For phosphórus, potassium, calcium, and magnesium determinations, a sample was wet-ashed by the perchloricnitric acid method and aliquots of the extract were analyzed. In the analysis for each of these elements the methods of Wolf and Ichisaka (1947) were used.

TABLE 2.—*Summary of treatments*

TREATMENT	DATE COMPLETE SOLUTION APPLIED	APPROX. TIME TO RECOVER	DATE DEFICIENT SOLUTION APPLIED	DATE SYMPTOM FIRST NOTED	APPROX. TIME SYMPTOM APPEARED
N-deficient	December 6, 1956—all replications	60 days	March 6, 1957		
	August 31, 1958—all replications	52 days	October 22, 1958	November 8, 1958	16 days
P-deficient	October 17, 1956—No. 100 and 126 only	Not yet [a]	October 30, 1956		
	November 29, 1956—No. 100 and 126 only	152 days [b]	May 1, 1957		
	August 31, 1958	238 days [b]	April 29, 1959	June 11, 1959	42 days
K-deficient	October 17, 1956—No. 96, 102, and 137 only	Not yet [a]	October 30, 1956		
	December 6, 1956—No. 96, 102, and 137	149 days	April 30, 1957	January 19, 1958	259 days
Ca-deficient	October 17, 1956—No. 99 only	Not yet	October 30, 1956		
	December 28, 1956—all replications	122 days [b]	April 30, 1957	October 17, 1958 [c]	527 days
Mg-deficient	December 6, 1956—No. 114 only	27 days	January 3, 1957	March 9, 1958 [c]	429 days
S-deficient	October 17, 1956—No. 116 and 165 (replacement)	—	October 30, 1956—No. 116 only		
	December 19, 1956—No. 116, 129, 165 only	240 days	July 19, 1957	April 29, 1958	250 days
Micro-nutrient deficient	December 28, 1956—all replications	Not yet	February 1, 1957		
	October 17, 1958—No. 173 only	192 days	April 29, 1959	June 11, 1959	42 days

[a] When application of deficient solution was resumed, the plants have not yet recovered.
[b] Plants also recovered from Helminthosporium leaf spot.
[c] Slight deficiency symptoms.

The different forms of carbohydrates were determined according to the A.O.A.C. (1945).

RESULTS

Visual Observations

General observations. In January, 1956, most plants were suffering from a fungus disease which, in the early stage, produced elliptical spots measuring from 3 to 5 mm. by 5 to 10 mm. They were burnt umber (Maerz and Rea-Paul, 1950: Pl 15, A-12)[2] on the upper surface of the leaf and sayal brown (Pl 13, G-9) on the lower surface. Each spot had a halo of water-soaked mustard color Pl 11 1-4). At this stage, the rest of the leaf was calla green (Pl 22, 1-4) on the lower surface and Lincoln green (Pl 23, 1-3) on the upper surface.

The old spots were 10 mm. or more in diameter. They were circular or irregular, especially when neighboring spots coalesced. The central portion were rose dust (Pl 6, A-2) with brown to black borders (Pl 48, L-12). The outlying areas which were in the early stage of degradation were orange (Pl 11, E-11) or chocolate brown (Pl 8, J-10). Fig. 1 shows representative leaflets in various degrees of spotting, and fig. 2 is a portion of a leaf with mild infection.

At first it was suspected to be a case of the bleeding disease of coconut (*Ceratostomella paradoxa*) on juvenile plants; but on closer study, the causal fungus was determined to be *Helminthosporium* sp.[1] The disease seemed to be most severe on plants maintained in potassium- and phosphate-deficient cultures. The lack of these nutrients *per se* brought about drying of the leaves; the apparent increase in susceptivity of these plants to the fungal infection aggravated it. The plants which seemed to suffer least from the disease were those in the minus-nitrogen treatment.

Another kind of spotting occurred during the dry months of February, March, April, and May of 1957. The older leaves of plants in almost all treatments developed elliptical specks of about one by two millimeters in size. The specks were at first yellow and translucent but they rapidly turned orange and ultimately brown (Pl 8,

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[2] All subsequent designations of color plates refer to Maerz and Rea-Paul, 1958.

[3] Thanks is due Mr. Gil Divinagracia for identifying it.

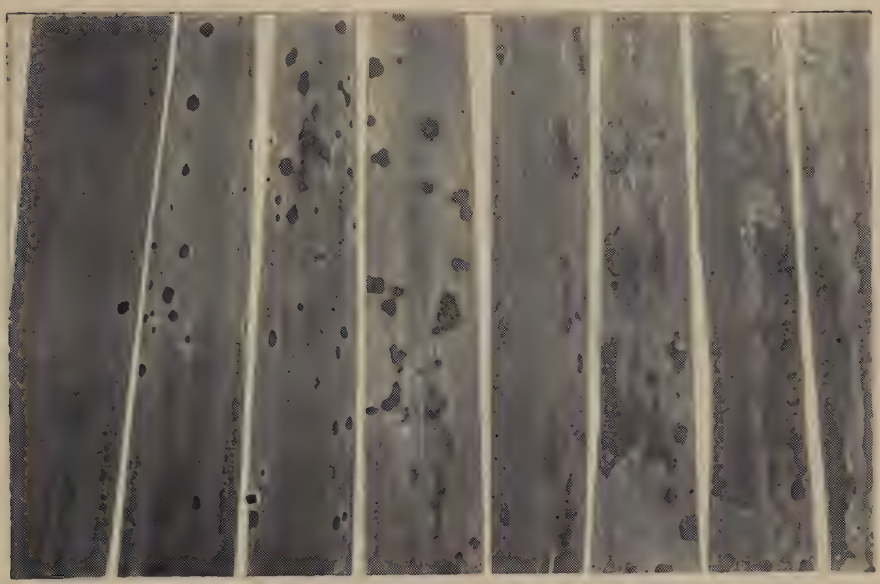

Fig. 1.—Leaflets of increasing severity of infection. Black spots or blotches with orange border.

Fig. 2.—Portion of a leaf with spots of *Helminthosporium* sp.

E-12) on the upper surface and water-soaked vandyke brown (Pl 7, A-11) on the lower surface. They were most marked on plants treated with magnesium-deficient solution, hence the suspicion that they might be caused by magnesium deficiency. On the assumption that even the complete Hoagland's solution was not supplying the coconuts enough magnesium, the writers raised the level of magnesium in all solutions to twice its original level. This alleviated but little the malady. Late in 1958 when the writers were reviewing the observations of the previous two years, they became impressed with the recurrence of the abnormality during the dry season and decided that probably the spots were brought about by the accumulation of salts in the sand as a consequence of too rapid evaporation during these months, coupled with insufficient water used in flushing out the residual salt in the sand. During the dry months of 1959, the sand was flushed out with water every other week. The treatment seemed to have obviated the difficulty.

A third case of deterioration was the occasional yellow or orange blotch noticed around the midrib of the older leaves of some plants. The blotches seemed to be most prevalent on plants which were not receiving nitrogen The mosaic appearance tended to suggest that they were virus in nature. On the other hand, their occurrence on old leaves and especially on nitrogen-deficient plants gave ground to the suspicion that they might be one aspect of protoplasmic degradation.

Complete. In September, 1956, the Helminthosporium leaf spot was noticed to be quite heavy on plant No. 156. Plants 103, 122, and 143 had light infections. The plants were pruned in order to minimize the source of inoculum. The latter three plants were noticed to have improved considerably in February, 1957 and practically freed of the leafspot. The former was so set back by the infection that even in January, 1958 when it had almost recovered from this, it was still much smaller than the other three.

Fig. 3 shows the relative sizes of a plant in this treatment after one and four years in the complete culture. (The drum which is 57 cm. in diameter can serve as an internal scale in these pictures). The plant at right is much smaller than a corresponding five-year old plant grown in the soil. This is because the root of the plant is pot bound. Even as early as the second and third year of treatment, the roots had already reached the bottom of the drums.

Fig. 3.—A plant receiving the complete solution after one and four years of treatment. Plant (a) is approximately two years of age. Note that the distal pinnae of the youngest leaf are still webbed.

The youngest leaf of this plant (fig. 4) is gracefully arched and the leaflets ascend at an angle of 45 degrees with the rachis. They are fairly long and pliant.

The following are the descriptions of the plants as they appeared on August 6, 1959:

Plant 122 had five exserted leaves; oldest leaf showed stubs of leaflets sampled for chemical analysis; distal leaflets, dried to almost lead grey (Pl 55, A-1); they had brown spots (Pl 1, C-9 to J-10) 3 by 5 mm., more or less grouped in colonies; basal leaflets, green. Next oldest leaf also showed stubs of leaflets sampled for analysis; similar to oldest leaf except that extent of drying was less. Third leaf, uniformly green (Pl 22, H-8 to L-9); some leaflets had dried patches, apparently attacked by leaf miner; rachis gracefully arched. Fourth leaf, lighter green than third (Pl 22, K-3 to L-5).

Fifth leaf, not fully expanded and leaflets still coherent at tips; leaflets even lighter green than fourth and the unexpanded ones almost yellow (Pl 19, E-4 to D-7).

Fig. 4.—Close-up of the youngest fully exserted leaf of plant with complete solution. Pinnae at 45° angle with rachis.

Plant 103 showed no marked differences from plant 122.

Plant 143 had profuse brown specks (Pl 7, C-10 to C-12), 1 by 2 mm.; specks tended to concentrate along margins of leaflets; even petioles had specks along the edges, which coalesce and form virtual stripes.

In general, the plants were well proportioned (fig. 3 and 4) and except for the drying old leaves, they may be considered of a normal green color. Fig. 17 indicates how the leaflets of the complete culture compare with homologous leaflets in the other treatments.

Minus nitrogen. In August, 1956, the plants were already yellow and the petioles of the yellow strain was bright orange. They were slender but not yet noticeably stunted. The webbed leaflets characteristics of seedling leaves persisted much longer in these plants than in other treatments. In January, 1957, the yellow mosaic blotches became noticeable in some plants. The incidence of Helminthosporium spots was quite rare.

The plant seemed to lack succulence (fig. 5). The young leaf was short and the yellow leaflets were stiff (fig. 6), and spread like a fan.

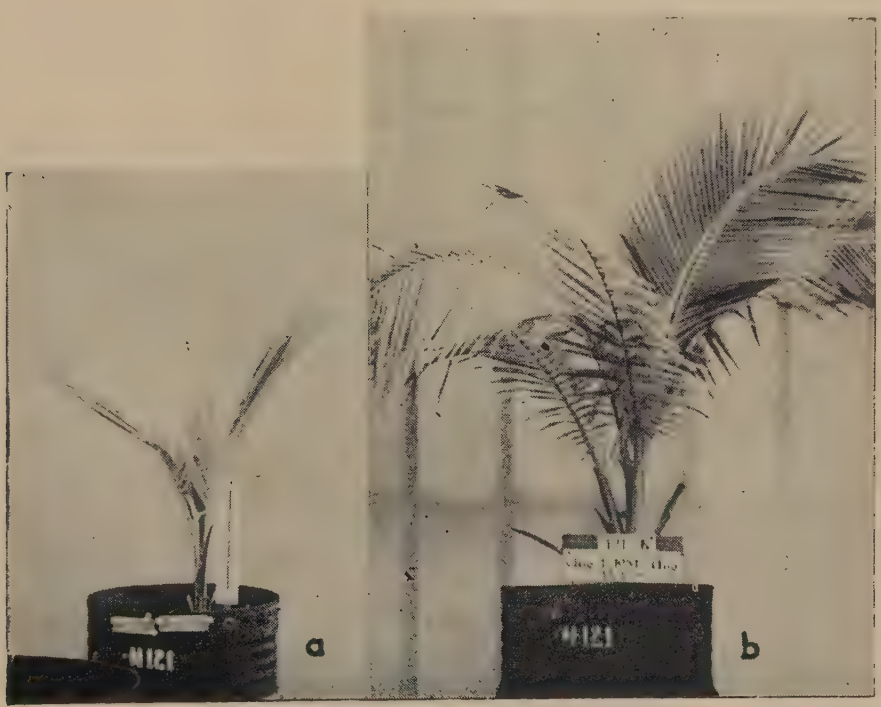

Fig. 5.—Plant receiving no nitrogen after one and four years of treatment. The slight arching of leaves of plant (b) was probably brought about by the application of complete solution for a short duration.

At the last observation (August 6, 1959), plant 121 had five exserted leaves; oldest leaf drying at distal end; parts of leaflets in initial stages of drying were yellow (Pl 12, L-4); yellowing, more intense along midrib; margins, light green (Pl 13, K-3); basal leaflets, light green with occasional light yellow spots which in some

places assumed a mosaic appearance. The next leaf had stubs of sampled leaflets; tips of distal leaflets, dried; undried portion, yellow (Pl 11, J-7); basal leaflets, light green (Pl 20, J-5). Third oldest leaf also had stubs of sampled leaflets; tips of leaflets drying; midrib region lighter green than margins. Fourth oldest leaf, gracefully arched—might have been brough about by a little nitrogen supplied to plants on August 31, 1958; leaflets, light green (Pl 20, K-6); mosaic blotches, much more pronounced than on older leaves. Youngest leaf, darker green than fourth leaf (Pl 21, I-27). Petiole of all leaves, canary yellow (Pl 11, L-3).

Fig. 6.—Close-up of youngest fully exserted leaf. Pinnae are short and rigid.

Plant 95 had oldest leaf in more advanced stage of drying than that of plant 121. Petiole color, almost yellow-green.

Plant 105, essentially the same as plant 121, except that petiole was ochre (Pl 11, L-9) and mosaic blotches were buff (Pl 11, K-7).

Plant 111, also similar to plant 121 except that the leaves were darker green (Pl 20, L-4).

Minos phosphate. Right at the start (August, 1956), plants No. 100 and 126 were unthrifty and heavily attacked by Helminthosporium leaf spot. Even the youngest unexpanded leaf had big disease spots . Plant 126 ultimately died and was replaced on November 21, 1956 with plant 170, which had hitherto been maintained in complete solution.

Although, in general the plants were stunted, they remained darker green than those in the complete culture. The old leaves died of severe drying and the leafspot disease; but unlike the other plants which underwent changes in shades of color from yellow to brown, they remained essentially dark-green until they ultimately and almost abruptly turned brown. Yellowing of the margins of leaflets in old deteriorating leaves was observed only during the dry months of March to May.

In the early stage, the plants were not distinctly different from those receiving the complete solution (cf. fig. 3 and 7). But in the later stages, there was much rosetting in the phosphate-deficient plants. The young leaf came out with difficulty, oftentimes remaining not fully exserted (fig. 8) while the succeeding one was already half-way out and its distal leaflets unfolded.

At the last observation, plant 117 had six exserted leaves; in general, petiole was short and leaflets closely set together. Oldest leaf was severely drying (firing) at distal end; heavily attacked by Helminthosporium disease; leaflets remained dark-green and hardly turned yellow before drying; basal leaflets dark green (Pl 22, I-6). Next leaf, more severely attacked by the disease so that leaflets appeared tattered. Third oldest leaf was previously sampled; distal leaflets, with disease spots and starting to dry; middle leaflets, dark green (P1 24, J-8) with occasional disease spots.

Plant 100 had five exserted leaves; bases, closely encased in "guinit" or stipule; severely attacked by Helminhtosporium disease. Oldest and next oldest leaves, drying; leaflets, very short.

Plant 115 seemed to be more vigorous than plant 117; about the same color of leaves; almost free from disease; petioles tended to be short and leaflets closely set.

Fig. 7.—Plant receiving no phosphate. Note the severe drying of old leaves and tendency of leaves (a) to form rosette.

Plant 126, had four exserted leaves; slightly better than plant 117 and almost like plant 115; showed attack of leaf-miner.

Because the leaves were dark green and in a rosette at this stage of severe phosphate deficiency, the symptoms were quite distinct from nitrogen deficiency. This is contrary to observations with corn or tomato where severe phosphate deficiency may be confused with severe nitrogen deficiency.

Minus potassium. In August, 1956, plant 102 was heavily attacked by Helminthosporium leaf spot. It was very small as a result of the continuous heavy pruning of infected parts. The deterioration was quite rapid and in October, only one leaf remained. The other three plants were normal at the start, but plants 96 and 137 became badly infected with Helminthosporium. They were given the complete solution for 149 days; this enabled them to recover con-

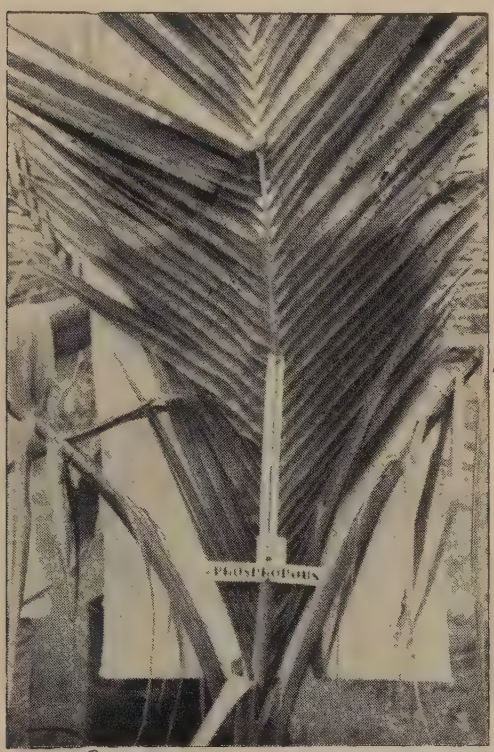

Fig. 8.—Close-up of youngest leaf. Note the crowding of pinnae and the short petiole. Exsertion is very much delayed

siderably. Plant 169 was not bothered by the disease but it exhibited the orange, brown, and black little spots along the margins (fig. 17) early in the experiment. However, it remained tall and comparable in size with those receiving the complete solution. It was only in August, 1959 when the older leaves dried very fast and the plant started to deteriorate (fig. 9b).

At the final observation, plant 169 had six exserted leaves; it was generally dark green and apparently normal like plants in the complete culture. Oldest leaf was severely drying at distal end; middle leaflets, green (Pl 24, L-8). Next leaf had dried or drying areas; drying started with the formation of brown areas (Pl 14, B-10) which developed into grey (Pl 6, A-7 on upper surface and D-6 on

lower surface). All the younger leaves were green (Pl 24, L-8) and without yellow or brown spots.

Fig. 9.—Plant receiving no potassium. Note drying (or firing) of old leaves.

Plants 96 and 102 were similar to plant 169; oldest leaf, also severely drying.

The oldest and next leaves of plant 137 were severely drying in extensive areas ("firing"); drying began as small and profuse pin-head-sized brown dots (Pl 7, E-12) which coalesced and formed dried brown areas (Pl 6, A-7). Third oldest leaf, had moderate Helminthosporium disease infection; middle leaflets, green (Pl 22, E-6). Youngest leaf had disease infection.

Minus calcium. In September, 1956, plant 99 was noticed to be attacked by Helminthosporium leaf spot. In addition, the leaflets tended to be narrow. The other plants of this treatment appeared normal. There was an imperceptible transformation of the plants into a tall slender form with rather sparse leaves. The irregular mosaic blotches along the midrib of leaflets were deep yellow to orange. They were more intensely colored than the blotches on the minus-nitrogen plants. Apparently anthocyanin is intensified with calcium deficiency. Except for the more rapid drying of older leaves, the plants seemed to remain normal up to the last observation (fig. 10b). Fig. 11 shows the slender and sparse young leaf, with leaflets ascending at an angle of almost 30 degrees with the rachis.

Fig. 10.—Plant receiving no calcium. Note long petiole and tucked-in leaves. Old leaves are drying.

At the last observation, plant 162 had four exserted leaves. Leaves tended to cluster together into a tuft giving the plant a tall

and slender appearance. Oldest leaf, drying at distal end; brown spots (Pl 15, A-8 to C-8), about 1 by 2 mm. in diameter, coalesced into extensive and irregular dried areas; petiole, green. Next leaf appeared brownish because of many spots, but background color was light green (Pl 14 J-2); leaflets seemed to lack water. Third leaf had three or four diseased spots; showed light green haze along midribs as if moderately infected; background color was green (Pl 22, H-7). Youngest leaf was apparently normal.

Plant 99 was similar to plant 162; petiole color, tuscan tan (Pl 13, D-8).

Plant 147 was similar to plant 162; petiole color, tan (Pl 12, B-1); young leaves, more pronouncely tucked in.

Plant 166 was the same as plant 162; oldest leaf had disease spots about 0.5 by 1 cm.

Minus magnesium. In August, 1956 and a few months after, plants 93, 98, and 114 were very healthy and tended to be bigger than the plants receiving the complete solution. However, plant 171 started with a heavy infection of Helminthosporium leaf spot. It died in September and was replaced with a new plant. The disease bothered the plants of this treatment but not as severely as those in the minus-phosphate and the minus-potassium cultures.

In October, 1956, water-soaked areas (fig. 17) appeared in the older leaves of all plants. This may be considered as one symptom of magnesium deficiency.

In May, 1958, the older leaves of all the plants in this treatment assumed bright color which soon turned brown (bronzing). They were very conspicuous and could be picked out from the rest of the plants even from a distance. This characteristic is reminiscent to that observed on coconuts in San Miguel Island, the supposed origin of cadang-cadang of coconuts.

At the last observation, they seemed to be normal, except for the drying of the older leaves (fig. 12b). Plant 114 had five exserted leaves. Oldest leaf, drying at distal end; drying started as profuse elliptical brown dots (cf. spotting due to salt accumulation); petiole color, cinnamon (Pl 12, E-7) next leaf, previously sampled for analysis; also drying and with profuse brown dots. Third oldest leaf had numerous spots; general color, garland green (Pl 22, H-7). Youngest leaf appeared normal, except for light blotches along mid-

rib; blotches probably related to those noted in nitrogen-deficient plants.

Fig. 11.—Close-up of youngest fully exserted leaf. Note pinnae ascending at 30° with rachis giving it a tucked-in appearance; also, relatively greater distance between pinnae.

Plants 93 and 98 were the same as plant 114, except that the petiole of the latter was lincoln green (Pl 23, J-4).

Minus sulfate. Even before the plants were transferred to the big drums, some plants in this treatment had turned chlorotic; the distal end of the leaves became greatly stunted so that the leaf approached the shape of a buri leaf (fig. 13a). The plants varied greatly in the time they responded to lack of sulfate. Plant 116 deteriorated rather fast and was replaced with a new plant on September 24, 1956. In December 1956, most of the plants had to be pruned heavily on account of the attack of Heltminthosporium leaf spot.

Fig. 12.—Plant receiving no magnesium. Except for the bright color of drying old leaves, the plant appears normal.

Yellowing developed imperceptibly. There was a tendency for the second and third youngest leaves to turn yellowish ahead of the others. It was a dirty yellow in which a green haze or mottling (especially along the midrib) was set on a yellow background. This is quite distinct from the clear yellow in nitrogen deficiency. By November, 1958, all the plants had turned yellow.

The leaves had short petioles and presented a rosette appearance (fig. 13b). Plants 116 and 145, however, differed from the other two replicates in that they produced slender, weak rachis which bent almost in a semi-circle (fig. 14).

Fig. 13.—Plant receiving no sulfate. Leaves tend to form rosette.

Fig. 14.—Close-up of plant to show very weak young leaf arching in almost a semi-circle.

At the last observation, plant 129 had five exserted leaves. It appeared stunted; petiole, exserted only about 15 cm. beyond the stipule or "guinit"; grape green (Pl 21, K-1); leaflets, conspinuously short. Oldest leaf, silver green (Pl 21, H-3) at basal region and yellow ochre (Pl 11, L-7) at distal region; distal leaflets, drying. Next leaf, previously sampled for analysis; color similar to oldest leaf. Third leaf, slightly arched; midrib region had mosaic yellow coloration, which were more profuse on the basal leaflets than either the middle or distal leaflets; middle leaflets had brown patches due to attack of leaf-miners. Fourth leaf, oil yellow (Pl 12, L-1 to L-3); arched lightly like the third oldest; yellow mosaic pattern, visible in region of midribs.

Plant 116 had six exserted leaves. Oldest and next oldest leaves similar to those of plant 129. Third leaf arched to almost a semi-circle (fig. 14). Fourth, fifth, and sixth leaf appeared normal.

Fig. 15.—Plant receiving no micro-nutrients. Note horizontal position of old leaves and distorted young leaf at (b).

Plant 145 had five exserted leaves; similar to plant 129 except that third leaf was arched into a semi-circle; oldest and next oldest leaves dried in extensive brown areas (Pl 14, A-10).

Plant 165 had four exserted leaves; similar to plant 129; mosaic yellow pattern, very visible in third leaf; plant, stunted.

Minus micro-nutrients. In September 1956, the plants were generally big and very similar to those receiving the complete solution

(fig. 15a). They varied greatly in susceptibility to the Helminthosporium leaf spot.

On October 7, 1958, plant 173 produced a young leaf with frizzled leaflets (fig. 16). The succeeding leaves became more and more sparse until only the rachis remained. The old leaves were weak and projected from the base almost horizontally (fig. 15b).

Fig. 16.—Close-up of young leaf with frizzled and brittle leaflets.

Of the micro-nutrients (boron, copper, manganese, molybdenum, and zinc) boron-deficiency was suspected to have caused the distortion of the young leaves. To confirm this suspicion, a solution of borax (5 ppm boron) was applied on the clasping leaf-bases. The subsequent leaves recovered from the abnormality.

At the last observation, plant 173 had five fully opened leaves. Oldest leaf, previously sampled; leaflets, short especially at distal end of leaf; with profuse brown dots (Pl 16, A-9 to A-12 on upper

surface and Pl 15, E-11 on lower surface). Second oldest leaf, more spindling than first; leaflets, malformed and brittle. Third, fourth, and fifth leaf, apparently normal and dark green. This was probably brought about by sprays of 10 ppm boron as borax. Youngest leaf still unopened appeared malformed, with leaflets rather coherent at tips.

Plant 109 had normal looking three oldest leaves; the third, however, showed signs of brittleness. The two youngest leaves were almost without leaflets; rachis, swollen and weak.

Plant 161 had six exserted leaves; five eldest leaves, normal and dark green. The sixth leaf was slightly malformed. The seventh leaf yet unopened, brittle, and malformed.

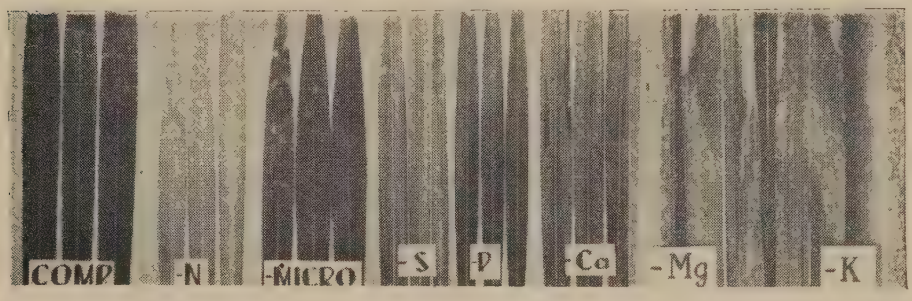

Fig. 17.—Comparative appearance of leaflets from third youngest leaves of the various treatments.

Plant 163 had four fully opened leaves. The fifth and sixth leaves still unopened but malformed; heavily attacked by Helminthosporium; almost dead.

Growth Measurement

Height. The heights of plants taken from the lid of the drum to the tip of the tallest leaf are graphically presented in figure 18. In general, the maximum height was attained some time in September, 1957. After this, the plants hardly grew and in the cases of minus-nitrogen, minus-phosphate, and minus-sulfate, the plants tended to decrease in height in 1959. The former period may be taken as the time when the roots were not yet bound, and the later period of hardly any growth probably indicates that the roots were pot bound. The decrease in height in some treatments at the end of observation

could mean that the deficiency of the particular nutrient was exerting marked adverse effect.

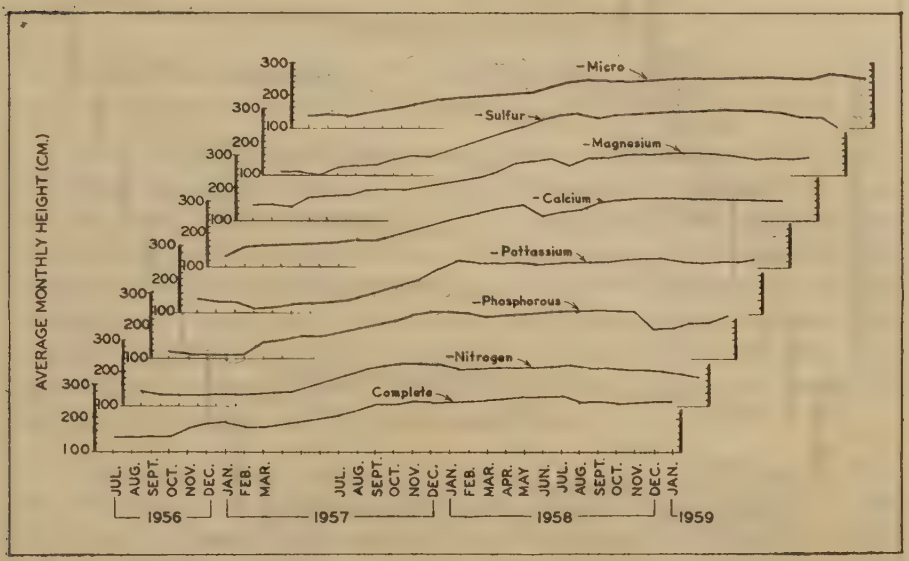

Fig. 18.—Average monthly height from the lid of the drum to the tip of the longest leaf

The minus-calcium and minus-magnesium plants were taller than those in the complete solution (control). Those in the minus-nitrogen, minus-phosphate, and minus-sulfate were shorter than the control.

Diameter of stem. Figure 19 indicates that there was, in general, a fairly rapid increase in stem diameter up to September 1957. Thereafter, the increase was slow but steady. With the exception of minus-nitrogen, there seemed to be little or no effect of treatment on this character.

Number of leaves. The number of leaves (fig. 20) assumed an approximately similar trend as the height of plants. The maximum number was attained in July to September, 1957. The number remained fairly steady up to November, 1958. Apparently, the number of new leaves produced just balanced the leaves which dried up. After this period, however, all treatments decreased in leaf number, except minus-phosphate.

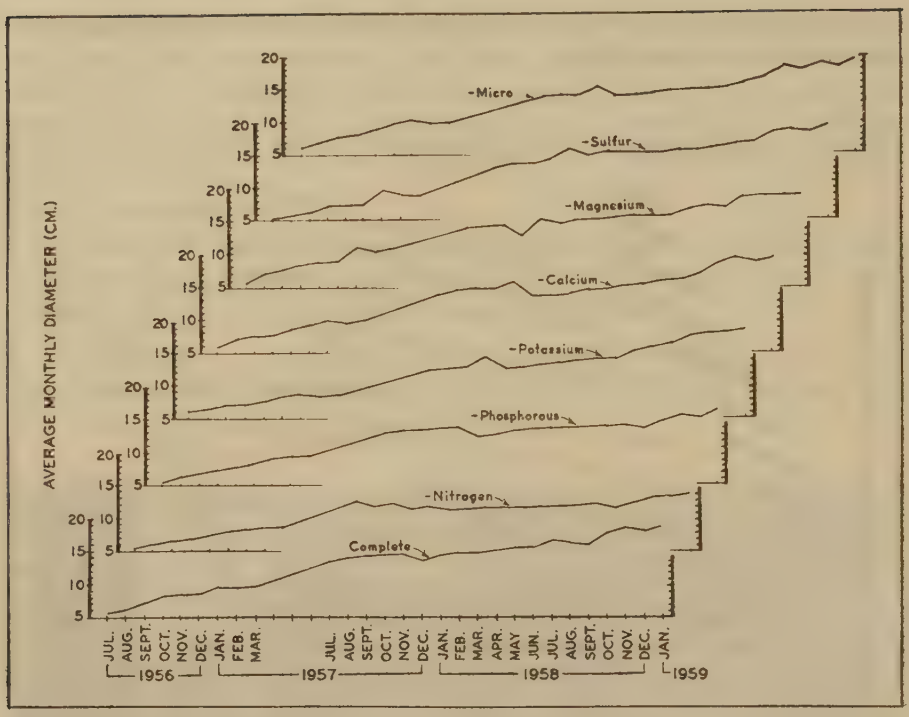
AVERAGE MONTHLY DIAMETER (CM.)
-Micro
-Sulfur
-Magnesium
-Calcium
-Potassium
-Phosphorous
-Nitrogen
Complete
JUL. AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. JUL. AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT. OCT. NOV. DEC. JAN.
1956 1957 1958 1959

Fig. 19.—Average monthly diameter of stem at the ground surface.

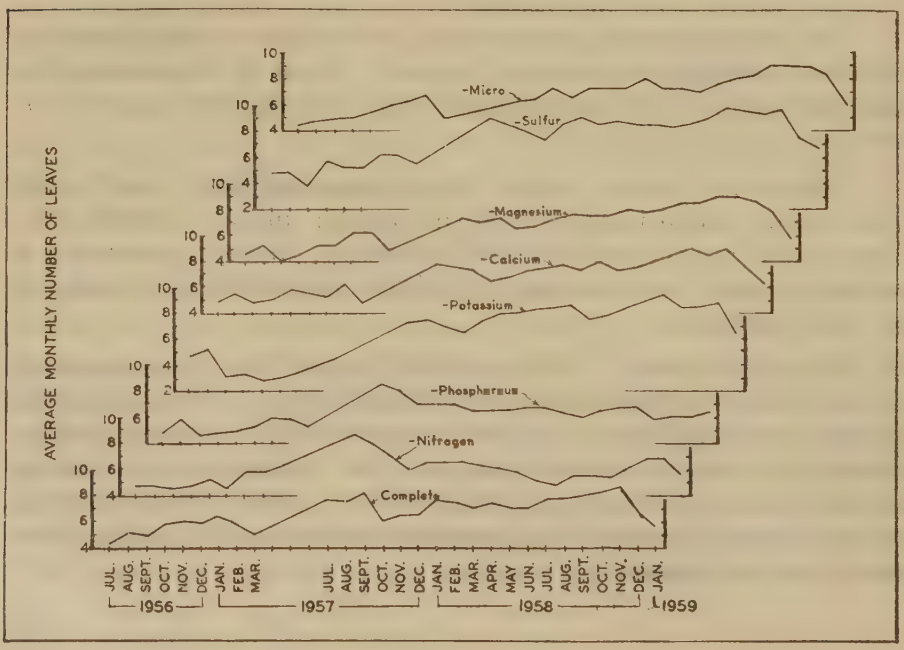
AVERAGE MONTHLY NUMBER OF LEAVES
-Micro
-Sulfur
-Magnesium
-Calcium
-Potassium
-Phosphorous
-Nitrogen
Complete
JUL. AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. JUL. AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT. OCT. NOV. DEC. JAN.
1956 1957 1958 1959

Fig. 20.—Average number of leaves in the different deficiency treatments.

The minus-nitrogen and minus-phosphate cultures had generally less leaves than the other treatments. On the other hand, the minus-sulfate plants ended to produce the most leaves.

Chemical Composition

Inorganic constituents. The analysis for total nitrogen, phosphorus, potassium, calcium, and magnesium are presented in table 3.

Total nitrogen was conspicuously low in the leaves of plants not receiving nitrogen (0.91 per cent). It was less than half of those receiving the complete solution. The minus-calcium plants tended to have less total nitrogen (1.54 per cent) than most other treatments. This may be a reflection of the part played by calcium in nitrogen utilization. Prevot and Ollagnier as cited by Baseden and Southern (1959) placed the critical nitrogen of leaves at 1.70 per cent. It is important to note that the average per cent nitrogen in these two cultures are below the critical level.

The phosphorus content of leaves was high in the young plant and progressively decreased with age. Mild nitrogen deficiency had no effect on phosphorus content but acute deficiency had apparently a marked adverse effect. As expected, phosphorus deficiency was reflected in low percentage of phosphorus in the leaves but the reduction was not striking (0.13 per cent vs. 0.17 per cent for the control). The other deficiency treatments seemed to have not affected the phosphorus content. Baseden and Southern reported 0.13 per cent phosphorus in leaves of trees bearing 0-15 nuts.

The potassium-deficient plants had 0.86 per cent potassium, which was less than half of those in the plants receiving the complete solution (2.00 per cent). There was also a tendency for potassium to be low in the minus-calcium and minus-magnesium plants. This, however, may be just fortuitous. Nitrogen deficiency tended to increase the percentage of potassium (2.35 per cent). The total content of potassium may not have been necessarily higher than the control, because the plants in this treatment were very much smaller. According to Baseden and Southern, potassium deficiency symptoms may occur when leaf potassium is 0.8 per cent.

Per cent calcium tended to be higher in the minus-nitrogen and minus-micronutrient plants than in the control. The minus-calcium plants had the lowest calcium content among the treatments. It was about three-fourths as much as the control. The minus-sulfur plants

TABLE 3.—*Percentages of the different elements in recently matured leaves of coconut receiving the different treatments and taken at different times of the year*

ELEMENT	SAMPLING [a]	COMPLETE	—NITROGEN	—PHOSPHATE	—POTASSIUM	—CALCIUM	—MAGNESIUM	—SULFATE	—MICRO
	1	2.06	1.08	1.62	1.89	1.50	1.73	1.65	1.96
	2	1.78	0.74	1.49	1.53	1.33	1.62	1.66	1.79
Per cent	3	1.81	0.72	1.93	2.02	1.62	1.72	1.71	2.00
Nitrogen	4	1.68	0.68	1.63	2.03	1.64	—	1.48	1.98
	5	2.19	1.42	2.04	1.85	1.62	1.96	2.41	1.88
	6	2.02	0.83	1.91	1.84	1.54	1.82	2.04	1.97
	Ave.	1.93	0.91	1.77	1.86	1.54	1.77	1.83	1.93
	1	0.30	0.30	0.25	0.32	0.26	0.32	0.24	0.29
	2	0.14	0.18	0.12	0.22	0.20	0.19	0.25	0.17
Per cent	3	0.20	0.17	0.12	0.19	0.19	0.18	0.18	0.19
Phosphorus	4	0.12	0.18	0.12	0.18	0.21	—	0.17	0.15
	5	0.13	0.08	0.06	0.07	0.07	0.09	0.11	0.12
	6	0.14	0.08	0.12	0.14	0.12	0.13	0.13	0.13
	Ave.	0.17	0.16	0.13	0.18	0.17	0.18	0.18	0.17
	1	—	—	—	—	—	—	—	—
	2	2.11	2.10	1.91	0.79	1.90	2.42	1.97	1.96
Per cent	3	2.82	3.45	2.11	—	2.31	2.40	3.60	2.70
Potassium	4	3.24	2.34	3.00	1.40	1.61	—	—	3.51
	5	0.63	1.89	1.31	—	1.18	1.23	0.87	1.19
	6	1.21	1.97	1.66	0.39	1.41	1.52	1.59	1.34
	Ave.	2.00	2.35	1.99	0.86	1.68	1.89	2.01	2.14
	1	0.39	0.37	0.32	0.35	0.33	0.35	0.29	0.45
	2	0.33	0.44	0.36	0.30	0.29	0.35	0.30	0.36
Per cent	3	0.40	0.54	0.43	0.38	0.30	0.39	0.31	0.42
Calcium	4	0.36	0.49	0.37	0.38	0.22	—	0.34	0.43
	5	0.45	0.15	0.18	0.43	0.26	0.37	0.36	0.53
	6	0.44	0.72	0.54	0.62	0.32	0.60	0.46	0.59
	Ave.	0.39	0.45	0.37	0.41	0.28	0.42	0.34	0.46
	1	0.27	0.17	0.16	0.26	0.25	0.16	0.20	0.28
	2	0.26	0.25	0.27	0.27	0.31	0.19	0.34	0.29
Per cent	3	0.25	0.31	0.27	0.31	0.33	0.09	1.19	0.24
Magnesium	4	0.09	0.16	0.12	0.16	0.13	—	0.08	0.16
	5	0.06	0.26	0.17	0.08	0.07	—	0.29	0.05
	6	0.30	0.25	0.24	0.30	0.27	0.09	0.30	0.24
	Ave.	0.21	0.23	0.21	0.23	0.23	0.13	0.24	0.21

[a] 1—July 19, 1957 3—Feb. 6, 1958 5—Nov. 29, 1958
2—Oct. 16, 1957 4—May 20, 1958 6—Sept. 3, 1959

tended to have less calcium than the control. All the other treatments may be considered as having the same content of calcium as the control.

The minus-magnesium treatment had about one-half as much magnesium as the plants receiving the complete solution. All the other treatments did not bring about an appreciable change in the percentage of magnesium in the plant.

Carbohydrate content. The different forms of carbahydrates may serve as indicators of metabolic activity in the plant. For instance, a high percentage of simple sugar may mean rapid production or ineffective polymerization. This aspect is also of interest on account of the claim that trees suffering from cadang-cadang (yellow decline of coconut) had lower contents of simple sugar and starch than the healthy plants.

Table 4 indicates that the reducing sugars in the minus-nitrogen,

TABLE 4.—*Per cent reducing sugar, total sugar, and starch in recently matured leaves of coconut receiving different treatments taken at different times of the year*

CONSTITUENT	SAMPLING [a]	COMPLETE	—NITROGEN	—PHOSPHATE	—POTASSIUM	—CALCIUM	—MAGNESIUM	—SULFATE	—MICRO
	1	3.20	2.68	3.85	3.56	3.42	2.82	3.59	2.07
Per cent	2	3.66	2.16	1.63	2.13	1.97	1.88	3.05	3.24
Reducing	3	2.57	2.15	2.26	3.27	2.86	2.27	2.15	2.81
sugar	4	1.19	1.04	1.21	1.26	1.08	—	1.28	1.02
	Ave.	2.66	2.01	2.24	2.56	2.33	2.32	2.52	2.28
	1	0.95	0.52	1.04	0.32	0.64	0.62	—	2.51
Per cent	2	2.14	1.78	1.74	1.10	—	0.47	1.63	3.36
Non-reducing	3	—	—	—	0.86	0.24	1.01	2.71	0.64
sugar	4	3.11	1.36	1.20	3.46	2.27	—	1.86	3.26
	Ave.	2.06	1.22	1.33	1.44	1.05	0.70	2.06	2.44
	1	4.15	3.20	4.89	3.88	4.06	3.44	4.87	4.58
Per cent	2	5.80	3.94	3.37	3.23	—	2.35	—	6.60
Total sugar	3	—	—	—	4.13	3.10	3.28	3.78	3.45
	4	4.30	2.40	2.41	4.72	3.35	—	3.99	4.28
	Ave.	4.75	3.18	3.55	3.99	3.51	3.02	4.22	4.73
	1	14.26	15.13	12.89	13.41	16.11	16.45	12.48	14.43
Per cent	2	16.35	17.38	15.04	18.47	14.98	12.75	14.80	15.45
Starch	3	14.70	16.31	14.54	13.62	14.62	14.20	14.16	13.37
	4	13.69	17.76	12.03	11.39	12.89	—	12.53	11.49
	Ave.	14.75	16.64	13.63	14.22	14.65	14.46	13.49	13.68

[a] 1—July 19, 1957
2—October 16, 1957
3—February 6, 1958
4—May 20, 1958

minus-phosphate, minus-calcium, minus-magnesium, and minus-micro-nutrient treatments were less than in the control, minus-potassium, and minus-sulfate treatments.

The non-reducing sugars of the minus-sulfate and minus-micro-nutrients were about equal to the control. All the other treatments had less non-reducing sugars than the latter.

In percentage of starch, the minus-nitrogen had much more than the control. The minus-potassium, minus-calcium, and minus-magnesium treatments may be considered as having equal starch content as the control. All the other treatments had less starch.

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AN ECONOMIC STUDY OF RETAIL STORES IN LOS BAÑOS AND CALAMBA, LAGUNA, AND SAN PABLO CITY, 1957 [1]

VICENTE U. QUINTANA [2]

Each store on the average handled 137 different items. Measured in terms of numbers of different items displayed for sale, the most important was cigarettes with 17 items.

The retail markup in a typical retail store amounts to about 11 per cent, assuming that the customer bought one from each group of items in that store. Canned meats and miscellaneous items were found to have the highest markups. Other items with high markups (21 per cent) were spices and peanut butter. Milk, rice, and tobacco products had the lowest percentage markups.

In the movement of products from the farm to the final consumers, the retail store is the last of the market agencies which are responsible for performing the marketing functions. The retailing of food products is coursed through thousands of small stores scattered all over the country. Thus stores handle a limited supply of food products and operate under highly unsatisfactory conditions in terms of food sanitation and efficient merchandising of food products. According to the 1948 census,[3] there were 128,984 retail stores, the majority of which were retailers of food items. More than four-fifths of these stores were operated by Filipinos who depended on retailing as a means of livelihood.

Efficient operation of the marketing system at the retail level is important in reducing marketing costs because a high proportion of the marketing changes are for retailing function. More efficient merchandising of food products will serve to lower prices to consumers and increase returns to producers. According to Brunk and Darrah,[4] improved merchandising techniques offer some possibilities for increasing the proportion of the consumers' income spent for farm products.

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[1] Central Experiment Station Contribution No. 2032.

[2] The author wishes to thank Dr. L. B. Darrah, Cornell Visiting Professor for his advice, and Professor P. R. Sandoval and Mr. F. A. Tiongson for their suggestions.

[3] Census of the Philippines: 1948, Economic Census Report, Vol. 4, p. 580.

[4] Brunk, M. E. and L. B. Darrah, "Marketing of Agricultural Products," Ronald Press Co., New York, 1955, p. 395.

To determine the number of items handled by food stores, enumerators visited 150 stores and counted the food items for sale. Anything taken in by mouth, except drugs, was considered a food item. Cigars and cigarettes were included. All retail stores from the main gate to Batong Malaki, Los Baños, were included in the samples. In San Pablo City, every third store was surveyed and in Calamba, every other store. In addition, in the last two places, the operators were interviewed to get information on wholesale and retail prices. The three places were made to represent the barrio, poblacion, and the city. Proximity to College was also a basis.

THE STUDY

Extent of service. The results revealed that regardless of whether it was in a barrio, a municipality, or a city, each store served around 15 families. The situation simply shows that the average retail store in the Philippines operates in a small area with only a limited number of customers to serve. By way of contrast, one retail store in the United States serves 100 [5] families on the average.

TABLE 1.—*Number of stores, population, and families per store, three areas, Laguna, 1957*

AREA	GOVERNMENT UNIT	STORES	ESTIMATED FAMILIES SERVED	FAMILIES PER STORE
Batong Malaki	Barrio	55	998	18
Calamba	Municipality	149	1286	9
San Pablo	City	261	3670	14

Commodities handled. The kind and the number of items sold have been ascertained for typical retail food stores. Each store on the average handled 137 different items. In counting the items, a large can of "sardines" counted as one item and a small can of the same brand was considered another. With cigarettes, each mark was considered a single item. Measured in terms of numbers of different items displayed for sale, the most important was cigarettes with 17 items, *patis* and soy sauce were second, candy was third, and sardines, fourth. The absence of adequate facilities for handling fresh food products resulted in the stores' handling primarily canned and other non-perishable items. Among the major

[5] United States Department of Agriculture, *The Yearbook of Agriculture*, 1954, 226.

canned food items, milk products, meats, fruits, vegetables, and crackers were relatively important. Fresh foods—meats, fish, fruits and vegetables—were a very insignificant portion of the items offered for sale.

TABLE 2.—*Kind and number of items offered for sale, 10 retail stores, Laguna, 1957*

ITEM	AVERAGE NUMBER OF ITEMS PER STORE	ITEM	AVERAGE NUMBER OF ITEMS PER STORE
Canned foods:			
Butter	2.0	Crackers and Biscuits	5.4
Cheese	1.0	Sausage (fresh)	0.5
Margarine	1.4	Sugar	3.9
Milk:		Cereals:	
Evaporated	3.5	Quaker oats	1.6
Condensed	2.0	Rice	2.9
Powdered	1.7	Corn	1.0
Ovaltine, Hemo	0.7	Eggs	1.3
Fish:		Baked goods	7.2
Salmon	2.0	Macaroni and Spaghetti, etc.	3.0
Sardine	6.6	Fish:	
Squid	1.5	Fresh	0.1
Others	2.3	Smoked	0.4
Lard & Oil:		Dried	0.6
Venus	1.0	Salted	1.2
Purico	1.8	Fresh foods:	
Whiteband	2.0	Vegetables:	
Cooking oil	2.3	Leafy	3.4
Patis & soy sauce	7.4	Rootcrops	1.1
Meat:		Fruits	2.2
Corned beef	2.9	Meat:	
Potted	2.3	Pork	0.1
Sausage	2.7	Beef	0.1
Pork & Beans	1.7	Poultry	—
Jam and Jellies	1.1	Others	—
Fruit	3.4	Drinks	4.7
Vegetables	5.1	Cigarettes	17.1
Soup	0.5	Candy	6.7
Coffee	3.4	Spices	3.1
Cocoa	1.2	Others, Coco, Vetsin, Gel	3.0
Total			137.0

Retail markups. The retail markup in a typical retail store amounts to about 11 per cent, if the customer bought one from each

group of items in that store (table 3). Canned meats and miscellaneous items were found to have the highest markups. Dairy products and canned meats had markups of more than 10 per cent. Beverages—coffee and cocoa—had the lowest percentage markups. In practice, however, the actual markup on the average item was substantial, but owing to the high price per unit, the relative markup was small. Large items usually had sizeable absolute margins.

TABLE 3.—*Average retail markup by classes of products, Laguna, 1957*

CLASS OF PRODUCTS	PERCENTAGE MARKUP FROM COSTS
Dairy products	10.5
Spreads (other than dairy)	11.6
Canned meat	12.0
Canned fish	10.4
Beverages	9.7
Others	11.8
Average	11.0

The margins for different items were obtained by subtracting the average wholesale prices from the corresponding average retail prices (table 4). The markup by items varied markedly. Spices and peanut butter were items with high markups, each with 21 per cent. Small cans of evaporated milk and patis and soy sauce had markups of 18 per cent, respectively. Milk, rice, and tobacco products had the lowest percentage markups.

The percentage markup and the absolute amount of markup are two completely different figures, the former is expressed in percentage while the latter is expressed in pesos or centavos. For low priced items, the percentage markup is usually large. For example, the average markup for a small can of milk was ₱0.03 per can at the time of the survey. This amount appears insignificant until one considers that it is equivalent to 18 per cent. In contrast, the absolute margin taken on "Eggo" amounted to ₱0.17 per unit. This seemingly large margin had a corresponding small percentage markup of 9 per cent. With the exception of few commodities, the average prices were for all sizes and varieties. The difficulty in classifying stemmed from the meagre selection of varieties and sizes of many stores so that very few data were made available.

TABLE 4.—*Wholesale and retail prices and percentage markup by products, Laguna, 1957*

PRODUCT	UNIT	NUMBER OF ITEMS	NUMBER OF STORES	AVERAGE WHOLESALE PRICE	AVERAGE RETAIL PRICE	AVERAGE MARGIN	PER CENT MARKUP
				pesos	*pesos*	*pesos*	
Dairy products:							
Butter	*	7	65	1.60	1.78	.18	11
Cheese	*	9	113	1.14	1.28	.14	12
Milk:							
Condensed:							
Large		6	136	.55	.60	.05	9
Small		3	34	.23	.26	.03	13
Evaporated:							
Large		6	142	.33	.37	.04	12
Small		5	107	.17	.20	.03	18
Powdered	*	11	87	1.72	1.85	.13	8
Other spreads:							
Margarine		1	145	.73	.80	.07	10
Peanut butter	*	3	9	.71	.86	.15	21
Jam and jellies	*	5	15	.52	.58	.06	12
Eggo	*	1	5	1.91	2.08	.17	9
Canned fish:							
Salmon	*	8	68	1.03	1.15	.12	12
Sardine	*	14	223	.35	.39	.04	11
Squid	*	11	160	.29	.33	.04	14
Canned meat:							
Corned beef	*	9	200	.73	.80	.07	10
Potted meat	*	7	147	.23	.26	.03	13
Pork and beans	*	9	80	.44	.50	.06	14
Other meat	*	21	82	.60	.66	.06	10
Lard and oil	*	14	341	.69	.75	.06	9
Patis and soy sauce	*	29	209	.31	.36	.05	16
Soup	*	3	9	.58	.64	.06	10
Beverages:							
Coffee	*	10	104	1.85	2.01	.16	9
Cocoa	*	8	160	1.05	1.17	.12	11
Crackers and biscuits	*	18	48	.59	.64	.05	9
Eggs	*	2	58	.14	.16	.02	14
Sausages	*	11	90	.44	.48	.04	9
Sugar	*	3	122	.37	.42	.05	14
Macaroni and spaghetti	*	10	94	.81	.92	.11	14
Rice	ganta	15	65	1.08	1.17	.09	8
Fish	*	8	18	.91	1.01	.10	11
Fruits	*	10	128	.75	.83	.08	11
Spices	*	10	109	.72	.87	.15	21
Cigars and cigarettes	*	23	179	.36	.39	.03	8

* All sizes.

APPRAISAL AND RECOMMENDATIONS

The results of this phase of the study seem to indicate minor as well as major problems in the food stores. The first problem is the multitude of small businesses that operate in food retailing. Because of limited space, small stores can only handle a limited number of items and can only expect a small volume of sales. This results in major inefficiencies in the distribution of food. Small businesses are not in a position to take advantage of improved merchandising technique because of ignorance. An operator is not aware that if he could establish a bigger and better store and operate it properly, he would likely find his efforts well rewarded. It would attract more customers and aside from this, he can take advantage of the economy of operating a large volume of business which will result in low cost per unit.

In most of the stores in the Philippines, price tags are absent on practically all of the products that are displayed for sale. To most Filipino customers, haggling over prices is common. A more efficient system would call for the computation of retail prices that would reflect costs and tack such prices on the goods for sale. Thus, all customers would know the prevailing prices and could buy with the assurance that they paid no more for the goods than their neighbors. Price tags will also cut short the time spent for purchasing a certain item.

Another problem is the unsanitary handling of many food products, particularly those uncanned. This involves the use not only of sanitary facilities and equipment but also of sanitary handling procedures and the employment of food handlers who are free from communicable diseases. A certificate of health from the medical officer should be required before one can be employed as a food handler.

A minor problem of food stores is the lack of operating capital. Customers usually get goods on credit, tying up operating capital and restricting retailers in buying stocks. The limited number of items handled is partly due to this financial handicap.

NOTE: BLACK SPOTS ON THE LEAVES AND GRAINS OF RICE PLANTS [1]

The occurence of black spots on the leaves and grains of rice plants (fig. 1 and 2) was first incidentally mentioned by Velasco and Holaso [2] in 1958. They suspected that it might be due to insufficient manganese in the culture solutions and further proposed to increase manganese in subsequent experiments to twice the amount recommended by Arnon (1938)[3] Despite this, the disease prevailed.

This is a report of further observation on the phenomenon. Apparently, the abnormality is not caused by a pathogenic organism because no disease organism could be detected or isolated from the spots. Usually the black spots started from the tip of the leaves (fig. 1, a and b) spreading downward along the margin. If, however, the leaves broke crosswise, a spot originated from the point of breakage in irregularly-shaped bands. In severe cases, necrotic patches (fig. 1, h to j) occurred along the margin, followed by drying of the affected leaves (fig. 1, k).

Plants were not affected during the seedling stage. Symptoms showed at the start of vegetative growth or at about 45 days old in the case of the variety Peta. Under Los Baños conditions, the most severe cases occurred at flower emergence. The leaves remain spotted up to grain maturity.

Spots at the tips of grains appeared at about a week after flower emergence and became distinct as the grains matured. A spot may not appreciably increase in area from its first appearance but it usually became more intensely black. Apparently, only the rice hulls were affected because the dehulled rice seeds of several varieties showed no symptoms (fig. 2). It may not be presumed, though, that the quality of the grain with black spots is the same as one without it.

Among the rice plants grown in culture solutions, Peta seemed to be the most affected. The next susceptible variety was Tjere mas followed by SK-36. Str. 482. Very few spots were noted in

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[1] Part of Project 21, Rice and Corn Production Program.
[2] J. R. Velasco and A. A. Holaso, *Philippine Agriculturist*, **49**, 145 (1958).
[3] D. I. Arnon, *Amer. Jour. Bot.*, **25**, 322 (1838).

Palawan, Kinandang Putí, and Magsanaya. Generally, the lowland variety or the late maturing variety was affected more than the early maturing rice plants.

Fig. 1.—Stages in the development of black spots on the leaves of rice plants. *a* and *b*, early development; *c* to *e*, spots in progress; *f* to *j*, advance stage; *k*, severe stage.

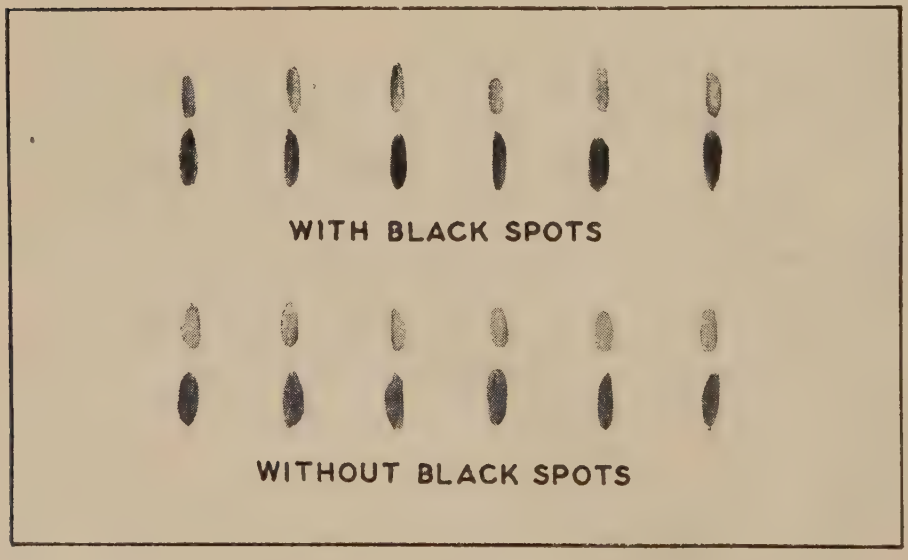

Fig. 2.—Appearance of grains with and without black spots.

Observations on the different culture solutions are given in table 1. Note that the severity of the disease seemed to be associated with high amount of nitrogen. RS-17 (high in nitrogen) promoted more spotting than culture XIII (high in potassium), and the latter more than cultures VIII (high in phosphorus) and XIX (medium in N-P-K); the least affected was culture XXV with 7×10^{-4} molar of silicate per liter of solution.

TABLE 1.—*Occurrence of black spots in rice plants grown in culture solutions*[a]

	RS-17	CULTURE XIII	CULTURE VIII	CULTURE XIX	CULTURE XXV
Character of culture solutions	High N	High K	High P	Medium in N-P-K	With Si
Total number of leaves	133.25	134.75	123.00	127.25	142.75
Number of leaves affected	77.50	56.00	41.25	30.50	34.70
Per cent of leaves affected	58.16	41.55	33.53	23.96	24.30
Size of patches in cm.	5.42	4.12	4.10	5.10	4.70

[a] Average of four replications.

A further study conducted in September, 1959 showed that increasing levels of silica (as sodium silicate) added to culture XIX, decreased severity of spotting (fig. 3).

Black spots were severe during the warm and moist months of July to September, when gutation was most profuse. During the cooler months spotting occurred only occasionally.

—*Eduvigis B. Pantastico*

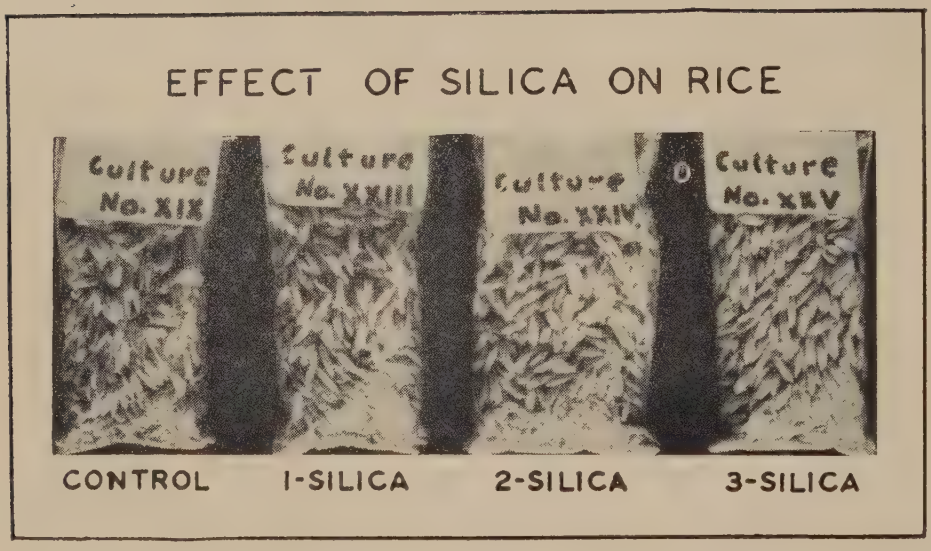

Fig. 3.—Spots on the grains of rice with increasing concentration of silica 1-silica received 2.7 × 10^{-4} M Na_2SiO; 2-silica with 5 × 10^{-4}; and 3-silica had 7 × 10^{-4}M.

NOTE: THE INTERFERENCE OF ALUMINUM IN THE MULDER BIOASSAY METHOD FOR COPPER

The following observation is an offshoot of the investigation in our laboratory of some relationships between copper and/or aluminum with the cadang-cadang disease of coconut.

Velasco (1957)[1] and Velasco, Palmquist, and Mamawal (1957)[2] used the *Aspergillus niger* bioassay technique (Kitchen, 1948)[3] for copper and found that it was lower in some Bicol soils than in those of Laguna and Quezon. The technique makes use of the fact that up to 2.5 micrograms of copper in 40 ml. of the medium, the spores increase proportionally in blackness.

On the other hand, when copper sulfate solution was applied to the cadang-cadang affected trees, the latter did not show any marked improvement. This may suggest that there could be some interference in the bioassay technique of copper determination or (if copper was intrinsically low) that a stronger limiting factor prevented the favorable response to the applied copper.

Further investigation of Bicol soil showed that aluminum was high in most samples (Velasco *et al.*, 1959a[4]; Velasco *et al.*, 1959b[5]). Tests for copper were made, therefore, in order to find if aluminum interferes with the *Aspergillus niger* method of determination.

Figure 1a shows that when 10 and 20 mg. of aluminum as aluminum sulfate were added to the cultures not receiving copper, the mycelium of *Aspergillus niger* became lighter than the culture which did not receive aluminum. Apparently, the incidental copper contamination in distilled water, sugar and salts which composed the medium was neutralized by the added aluminum. Again, when these amounts of aluminum were added to cultures which received 2 micrograms of copper as copper sulfate, there was a decrease in the intensity of color in the spores.

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[1] J. R. Velasco, *Philippine Agriculturist*, **41**, 157-170 (1957).
[2] J. R. Velasco, E. M. Palmquist, and E. B. Mamawal, *Philippine Agriculturist*, **41**, 241-243 (1957).
[3] H. B. Kitchen, *ed.*, "Diagnostic Techniques for Soils and Crops," The American Potash Institute, Washington 6, D.C., 1948.
[4] J. R. Velasco, A. Holaso, R. S. de la Peña, E. Pantastico, and V. F. Guevara, *Philippine Agriculturist*, **43**, 177-199 (1959).
[5] J. R. Velasco, R. K. de la Fuente, E. Pantastico, R. S. de la Peña, and A. Alfonso-Alejar. *Philippine Agriculturist*, **43**, 433-445 (1959).

0 Cu 0 Al
0 Cu 10 mg Al
0 Cu 20 mg Al
2 µgm Cu 0 Al
2 µgm Cu 10 mg Al
2 µgm Cu 20 mg Al
DATE INOCULATED: NOVEMBER 13, 1959
DATE PHOTOGRAPHED: NOVEMBER 18, 1959

Fig. 1a

Figure 1b shows that up to 7.5 mg. of aluminum, the increasing level of the element had an inverse effect on the intensity of spore color in cultures which received 0.5 micrograms of copper. In the early stages, the cultures which received 10 and 20 micrograms of aluminum were also included in the trend; later on, they become darker than the other aluminum cultures. There seems to be no immediate explanation for this.

—J. R. Velasco, R. K. de la Fuente, and R. S. de la Peña

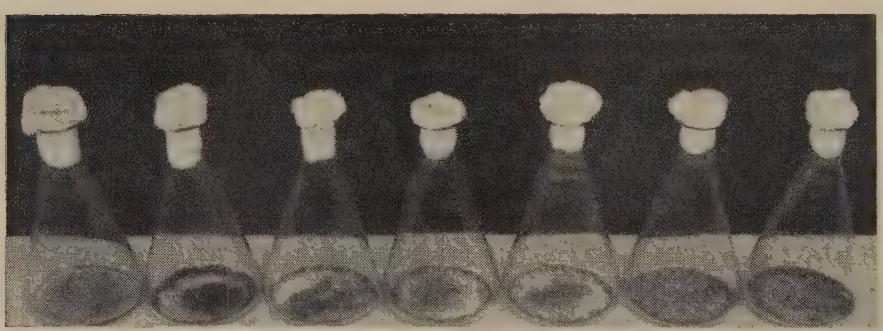
0 Cu 0 Al
5 µgm Cu 0 Al
.5 µgm Cu 2.5 mg Al
.5 µgm Cu 5.0 mg Al
.5 µgm Cu 7.5 mg Al
.5 µgm Cu 10 mg Al
.5 µgm Cu 20 mg Al
DATE INOCULATED: DECEMBER 12, 1959
DATE PHOTOGRAPHED: DECEMBER 16, 1959

Fig. 1b

ERRATA

In volume XLIII, No. 7, December 1959 number of *The Philippine Agriculturist*, p. 446, lines 16-17 (abstract) and p. 466, line 23, the dosage of insecticides may be considerably reduced so as . . . should read the dosage of insecticides should be adjusted so as; p. 446, footnote 2, Grateful acknowledgment is due Dr. Lewis A. Schafer and Mr. Mario O. San Juan, thesis senior advisers for helping plan the research work; p. 451, title of table 2, p. 452, title of table 3, p. 455, title of table 5, Quell should read Quel.; p. 457, caption of fig. 1, *Trotter* should read Trotter; p. 453, line 11, mongo leaves should read mango leaves; p. 465, lines 11-12, *Lepiota* was observed, the general appearance of which was very similar to *Manilia fimicola* . . . should read *Lepiota* was observed, but no caution seemed warranted. On this same bed, a *Monilia* species was also observed, the general appearance of which was very similar to *Monilia fimicola*.

In volume XLIII, No. 8, January 1960 number of *The Philippine Agriculturist*, p. 532, Appendix "A", Leaf Class B, Drill should read Dull.

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